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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/099,721	03/14/2002	Gregory E. James	NVIDP074/P000427	1906

28875 7590 06/16/2006

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EXAMINER	
GUILL, RUSSELL L	
ART UNIT	**PAPER NUMBER**
2123	

DATE MAILED: 06/16/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	10/099,721	JAMES, GREGORY E.
	Examiner	Art Unit
	Russ Guill	2123

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *22 May 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-33* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-33* is/are rejected.

7)☒ Claim(s) *10 and 11* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *14 March 2002* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

1. This non-final Office Action is in response to an Amendment filed May 22, 2006. Claims 32 and 33 were added. No claims were canceled. Claims 1 - 33 are pending. 1 - 33 have been examined. Claims 1 - 33 have been rejected. Claims 10 and 11 are objected to.

2. **The Examiner would like to thank the Applicant for the well-presented response, which was useful in the examination process. The Examiner appreciates the effort made to perform a careful analysis and present clear arguments.**

3. The Examiner has considered application numbers 10/098,833 and 10/099,770 submitted on the Information Disclosure Statement (IDS) dated June 19, 2002. The IDS has been placed in the application file.

4. The prior art made of record and not relied upon is considered pertinent to the applicant's disclosure:

   a. Rumpf, Martin and Strzodka, Robert; "Using Graphics Cards for Quantized FEM Computations"; September 3 - 5, 2001, Proceedings of the IASTED International Conference on Visualization, Imaging and Image Processing; specifically teaches using graphics cards to solve partial differential equations

   b. M. Rumpf and R. Strzodka; "Nonlinear Diffusion in Graphics Hardware", 2001, Proceedings of EG/IEEE TCVG Symposium on Visualization; specifically teaches using graphics cards to solve partial differential equations

Response to Remarks

5. As an initial matter, the Examiner would like to draw attention to new rejections made under 35 U.S.C. § 101.

6. Regarding **claim 1** rejected under 35 USC § 103:

   a. The Applicant argues:

      i. With respect to the first element of the *prima facie case of* obviousness, the Examiner states that "the motivation to use the art of Trendall with the art of Press would have been the benefit recited in Trendall that calculations on functions or vector fields can be

performed very quickly in graphics hardware." Applicant respectfully disagrees with this proposition, especially in view of the vast evidence to the contrary.

For example, Press relates to implementing mathematics in software, while Trendall relates to graphics hardware that implements different mathematics. To simply glean features from graphics hardware that implements different mathematics, such as that of Trendall, and combine the same with the *non-analogous* art of software-implemented mathematics, such as that of Press, would simply be improper. Graphics hardware implements mathematics in a hardware environment for improving hardware graphics processing, while software-implemented mathematics merely relates to using software to carry out mathematic operations. "In order to rely on a reference as a basis for rejection of an applicant's invention, the reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem with which the inventor was concerned." In re Oetiker, 977 F.2d 1443, 1446, 24 USPQ2d 1443, 1445 (Fed. Cir. 1992). See also In re Deminski, 796 F.2d 436, 230 USPQ 313 (Fed. Cir. 1986); In re Clay, 966 F.2d 656, 659, 23 USPQ2d 1058, 1060-61 (Fed. Cir. 1992). In view of the vastly different types of problems software-implemented mathematics addresses as opposed to graphics hardware-implemented mathematics, the Examiner's proposed combination is clearly inappropriate.

(1) The Examiner respectfully replies:

(a) The Applicant appears to recite that the art of Press relates to software-implemented mathematics while the art of Trendall relates to hardware-implemented mathematics. The Examiner notes that an ordinary artisan at the time of invention would have known that the software mathematics of Press was implemented on hardware, and therefore, the art of Press also relates to hardware-implemented mathematics. Further, the Trendall reference clearly teaches that graphics hardware is useful for general mathematical calculation. Just to select a few examples from the reference:

(i) "General calculations using graphics hardware", page 1, title.

(ii) "The current paper's contributions are (a) to show how general calculations can be done with current hardware," page 1, section Introduction, fourth paragraph.

(iii) "This paper has shown that graphics hardware can be used to perform complex calculations," page 10, section 6 Discussion, first paragraph.

(iv) "Generally speaking, when speed of calculation is more important than precision, mathematics on current graphics hardware can be very useful," page 10, section 6 Discussion, second paragraph.

Therefore, the Trendall reference is certainly pertinent to implementing software mathematics.

b. The Applicant argues:

i. Further, by virtue of the sole focus of Press on software-implemented general mathematics, it is further argued that Press *teaches away* from the graphics hardware-oriented mathematics of Trendall and the claimed invention. *In re Hedges, 783 F.2d* ***1038,*** *228 USPQ* ***685*** *(Fed. Cir. 1986).*

(1) The Examiner respectfully replies:

(b) First, as recited above, Press teaches hardware implemented mathematics, and so does not teach away from hardware oriented mathematics. Second, the teachings of Press do not criticize, discredit, or otherwise discourage hardware implemented mathematics, and therefore cannot be held to teach away from hardware implemented mathematics.

c. The Applicant argues:

i. Applicant respectfully asserts that it would have been ***unobvious*** to incorporate the partial differential equations from Press in the graphics hardware environment of Trendall, since only applicant has recognized the benefits of the same. Specifically, solutions to partial differential equations, in the graphics hardware environment context claimed by

applicant, provide numerous *optional* advantages such as providing for more effective determination of a location of objects or surfaces to be rendered (as well as other possible advantages, etc.). Note the originally filed specification. Only applicant teaches and claims such a combination of features and components for the generation or computation of partial differential equation solutions for such purpose.

(1) The Examiner respectfully replies:

(c) Please refer to the rejection of claim 1 below that demonstrates that it would have been obvious to use the art of Trendall with the art of Press to produce the claimed invention.

d. The Applicant argues:

i. More importantly, with respect to the third element of the *prima facie* case of obviousness, the Examiner has relied on the Trendall reference to make a prior art showing of applicant's claimed technique "processing the input to generate the solution to the partial differential equation utilizing the hardware graphics pipeline" (see this or similar, but not necessarily identical language in the independent claims).

ii. Applicant respectfully asserts that the Trendall reference merely teaches "[g]eneral calculations using graphics hardware" (Page 1, Title) to "accelerate the rendering process much earlier than at the latter image generation stages" (Page 1, Abstract). In particular, Trendall suggests that "an RGB or RGBA image can represent a three or four dimensional vector field defined over a subset of the plane" which is beneficial since "operations on an image are highly parallelized and calculations on entire functions or vector fields can be performed very quickly in graphics hardware" (Page 3, Section 3). However, these general calculations of the cited excerpts simply fail to disclose "processing the input to generate the solution to the partial differential equation utilizing the hardware graphics pipeline" (emphasis added), as claimed by applicant.

(1) The Examiner respectfully replies:

(d) First, the Trendall reference clearly teaches that graphics hardware is useful for general mathematical calculation, not just to

accelerate the rendering process. Just to select a few examples from the reference:

(v) "General calculations using graphics hardware", page 1, title.

(vi) "The current paper's contributions are (a) to show how general calculations can be done with current hardware," page 1, section Introduction, fourth paragraph.

(vii) "This paper has shown that graphics hardware can be used to perform complex calculations," page 10, section 6 Discussion, first paragraph.

(viii) "Generally speaking, when speed of calculation is more important than precision, mathematics on current graphics hardware can be very useful," page 10, section 6 Discussion, second paragraph.

(e) Second, calculation of a caustic does "generate the solution to the partial differential equation," because a caustic is a solution to a partial differential equation.

e. The Applicant argues:

i. Furthermore, Trendall suggests using "a continuous approximation to the spreading of light after refraction, which leads to an integral that can be discretized" (Page 3, Section 2.2 – emphasis added) and that "the heightfield norrnals are calculated by convolving to get the x and y discrete partial derivatives, and then using pixel texturing to look up the associated normal" (page 8, Section 4.2). Trendall's suggestion of calculating heightfield normals by convolving clearly fails to meet "processing the input to generate the solution to the partial differential equation utilizing the hardware graphics pipeline" (emphasis added), as claimed by applicant.

(1) The Examiner respectfully replies:

(f) On page 8, section 4.2 Hardware Algorithm, Trendal provides the algorithm to calculate a caustic. Calculation of a caustic does process the input to generate the solution to a partial differential equation, because a caustic is a solution to a partial differential equation. However, in

addition, the Press reference is also relied upon the teach processing the input to generate the solution to a partial differential equation, in combination with Trendall to provide the use of graphics pipeline hardware. Further, it was old and well known in the art at the time of invention to use graphics hardware programming to solve non-graphics problems (Kedem, 1999; and Lengyel, 1990; and Bohn, 1998), including physical simulations (Ide, et al.; 2000), because of the superior speed of processing on graphics hardware. As demonstrated in the previously mentioned references, it was old and well known in the art to implement known algorithms on faster processors when they became available, and indeed, that is the reason that faster processors are developed.

f. Regarding claim 1, Applicant's arguments have been fully considered (see above) and are not persuasive. Accordingly, the rejection is maintained.

7. Regarding **claim 10**, rejected under 35 USC § 103:

a. The Applicant argues:

i. Applicant respectfully asserts that the excerpts from Ewins relied upon by the Examiner merely teach techniques for creating MIP-maps and performing bilinear and tilinear filtering. Ewins teaches that MIP-maps consist of "the prefiltering and storage of multiple texture traps of decreasing resolution which attempt to contain the same information in an increasingly smaller space" which is accomplished by "progressively <u>averaging groups of four neighboring textels</u> to format each new layer of the image pyramid" (emphasis added). However, "averaging groups of four neighboring textels" simply fails to meet a technique "wherein the <u>local area of textures</u> is filtered utilizing a <u>filter including a plurality of elements</u>" (emphasis added), as claimed by applicant.

(1) The Examiner respectfully replies: Applicant's arguments have been fully considered and are persuasive. Accordingly, the rejection is withdrawn.

8. Regarding **claim 11**, rejected under 35 USC § 103:

a. The Applicant argues:

i. Further, with respect to Claim 11, the Examiner has relied on pages 318-319, section 1.1 Texture Filtering, from the Ewins reference to make a prior art showing of applicant's claimed technique "wherein the local area of textures is used to sample a texture map to generate a modified local area of textures."

ii. Again, applicant respectfully asserts that the excerpts from Ewins relied upon by the Examiner merely teach techniques for creating MIP-maps and performing bilinear and trilinear filtering. Ewins further discloses that MIP-maps are foamed by "averaging groups of four neighboring textels" and "[t]rilinear interpolation is then achieved by linearly interpolating between the color values resulting from these two bilinear interpolations to the intermediate interpolation fraction f as shown" (emphasis added). However, the MIP-maps, bilinear, and trilinear filtering simply fail to even suggest a technique "wherein the local area of textures is used to sample a texture map to generate a modified local area of textures" (emphasis added), as claimed by applicant.

(1) The Examiner respectfully replies: Applicant's arguments have been fully considered and are persuasive. Accordingly, the rejection is withdrawn.

Specification

9. The disclosure is objected to because of the following informalities: On page 11, line 14, and also page 16, line 15, the specification recites a "discreet grid." Appropriate correction is required.

Claim Rejections - 35 USC § 112

10. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

a. Claims 1 - 33 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

i. Claims 1 and 26 – 30 recite, "for enhancing graphics processing operations performed by the hardware graphics pipeline." The specification does not appear to describe "enhancing graphics pipeline operations."

11. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

a. Claims 1 - 33 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

i. Regarding claims 1 and 26 – 30, the claims recite, "the solution to the partial differential equation is generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline." The statement appears to be circular because it utilizes the hardware graphics pipeline to enhance graphics processing operations performed by the hardware graphics pipeline. The metes and bounds of the limitation cannot be clearly determined. Further, it is unclear whether the "enhancing graphics operation" is an intended use or an actual use. For the purpose of claim examination, the phrase is interpreted as "the solution to the partial differential equation is generated utilizing the hardware graphics pipeline, and the solution to the partial differential equation is generated to enhance graphics processing operations performed by the hardware graphics pipeline." Correction or amendment is required.

Claim Rejections - 35 USC § 101

12. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

13. **Claims 1 - 25, 28 - 29 and 32 - 33** are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter.

   a. Regarding **claims 1 - 25, 28 - 29 and 32 - 33**, the claims do not appear to produce a tangible result to form the basis of a practical application needed to be statutory. Generating or computing a solution does not appear to produce a tangible result. Further, enhancing graphics processing operations does not appear to produce a tangible result.

Claim Rejections - 35 USC § 103

14. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

15. **Claims 1 - 2, 12 - 18, 22 - 23, 27 and 32 - 33** are rejected under 35 U.S.C. 103(a) as being unpatentable over Press (Press, William H.; Flannery, Brian P.; Teukolsky, Saul A.; Vetterling, William T.; "Numerical Recipes in Fortran 77", 2001, Second edition, Cambridge University Press) in view of Trendall (Trendall, Chris; Stewart, A. James; "General Calculations using graphics hardware, with application to interactive caustics", June 2000, "Rendering Techniques 2000: 11th Eurographics Workshop on Rendering").

   a. Regarding **claim 1**:

   b. Press appears to teach:

      i. Receiving input (<u>pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that input is required to solve a partial differential equation, especially given the statement that an initial distribution relaxes to an equilibrium distribution on page 855</u>);

ii. Processing the input to generate the solution to the partial differential equation (pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems);

iii. Wherein the solution to the partial differential equation is generated (pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems);

c. Press does not specifically teach:

i. Receiving input *in the hardware graphics pipeline;*

ii. Processing the input to generate the solution to the partial differential equation *utilizing the hardware graphics pipeline;*

iii. Wherein the solution to the partial differential equation is generated *utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline*.

d. Trendall appears to teach:

i. Receiving input in the hardware graphics pipeline (*page 9, section 5 Implementation results, first paragraph; page 7, second paragraph that starts with "Since the imaging pipeline . . ."; it would have been obvious that in order for the pipeline to perform a convolution that input was received*);

ii. Processing the input to generate the solution to the partial differential equation utilizing the hardware graphics pipeline (*page 1, Title; page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

iii. Wherein the solution to the partial differential equation is generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline (*page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

e. The motivation to use the art of Trendall with the art of Press would have been the benefit recited in Trendall that calculations on functions or vector fields can be performed very quickly

in graphics hardware (*page 3, section 3 Mathematical capabilities of graphics hardware, third paragraph*).

f. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Trendall with the art of Press to produce the claimed invention.

==

g. Regarding **claim 2**:

h. Press appears to teach:

i. Input represents boundary conditions (pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that boundary conditions are required to solve a partial differential equation, especially since the title of the section recites Boundary Value problems);

==

i. Regarding **claim 12**:

j. Press appears to teach:

i. The processing includes a relaxation operation (pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that processing includes a relaxation operation, especially since the title of the section recites Relaxation Methods);

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k. Regarding **claim 13**:

l. Press appears to teach:

i. The relaxation operation is selected based on the partial differential equation (pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that the relaxation operation is selected based on the partial differential equation, especially since such an example is presented);

===

m. Regarding **claim 14**:

n. Press appears to teach:

i. The processing includes a plurality of iterations of the relaxation operation (**pages 854-856, section 19.5 Relaxation Methods for Boundary Value Problems; especially references to Gauss-Seidel method and Jacobi's method**);

===

o. Regarding **claim 15**:

p. Press appears to teach:

i. A number of iterations of the relaxation operation is reduced using at least one of a prolongation operation and a restriction operation (**pages 862-868, section 19.6 Multigrid Methods for Boundary Value Problems, especially page 865 Smoothing, Restriction and Prolongation Operators**);

===

q. Regarding **claim 16**:

r. Press appears to teach:

i. The processing further includes determining whether the solution has converged (**pages 855, Relaxation Methods for Boundary Value Problems; second paragraph, section that starts with "Thus the algorithm consists . . .", sentence, "This procedure is then iterated until convergence."**);

===

s. Regarding **claim 17**:

t. Press appears to teach:

i. It is determined whether the solution has converged after each iteration of the relaxation operation (**pages 855, Relaxation Methods for Boundary Value Problems;**

second paragraph, section that starts with "Thus the algorithm consists . . .", sentence, "This procedure is then iterated until convergence.");

==

u. Regarding **claim 18**:

v. Press appears to teach:

i. It is determined whether the solution has converged after a predetermined number of multiple iterations of the relaxation operation (pages 855, Relaxation Methods for Boundary Value Problems; second paragraph, section that starts with "Thus the algorithm consists . . .", sentence, "This procedure is then iterated until convergence.");

==

w. Regarding **claim 22**:

x. Press appears to teach:

i. If it is determined that the solution has converged repeating the processing using an altered parameter value operation (pages 862-868, section 19.6 Multigrid Methods for Boundary Value Problems; it would have been obvious to altering a grid size is altering a parameter);

==

y. Regarding **claim 23**:

z. Press appears to teach:

i. The number of iterations of the relaxation operation is determined prior to the processing (pages 860, Relaxation Methods for Boundary Value Problems; code example with a parameter value MAXITS = 1000 and a loop DO N=1,MAXITS);

==

aa. Regarding **claim 27**:

i. Claim 27 is taught as in claim 1 above.

==

bb. Regarding **claim 32**:

i. Trendall appears to teach:

(1) The graphics processing operations performed by the hardware graphics pipeline are enhanced by determining a location of surfaces rendered utilizing the solution to the partial differential equation generated utilizing the hardware graphics pipeline (**page 8, section 4.3 heightfield generation; a heightfield is a solution to a partial differential equation and is a surface rendered**);

==

cc. Regarding **claim 33**:

i. Trendall appears to teach:

ii. The graphics processing operations performed by the hardware graphics pipeline are enhanced by determining a location of objects rendered utilizing the solution to the partial differential equation generated utilizing the hardware graphics pipeline (**page 8, section 4.3 heightfield generation; a heightfield is a solution to a partial differential equation, and is an object rendered**);

16. **Claims 19 - 21** are rejected under 35 U.S.C. 103(a) as being unpatentable over Press and Trendall as applied to claims **1 - 2, 12 - 18, 22 - 23, 27** and **32 - 33** above, further in view of Roy-Chowdhury (Roy-Chowdhury, Amber; Bellas, Nikolas; Banerjee, Prithviraj; "Algorithm-Based Error-Detection Schemes for Iterative Solution of Partial Differential Equations", 1996, IEEE Transactions on Computers, Vol. 45, No. 4).

a. Regarding **claim 19**:

b. Press does not specifically teach:

i. The determining whether the solution has converged includes calculating errors;

c. Roy-Chowdhury appears to teach:

i. The determining whether the solution has converged includes calculating errors (page 400, left-side column, top-half);

d. The motivation to use the art of Roy-Chowdhury with the art of Press would have been the benefit recited in Roy-Chowdhury that the presented algorithm-based fault tolerance is an inexpensive method of achieving fault tolerance without requiring any hardware modifications, especially for iterative solution of linear systems arising from discretization of partial differential equations (page 394, Abstract).

e. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Roy-Chowdhury with the art of Press and Trendall to produce the claimed invention.

==

f. Regarding **claim 20**:

g. Press does not specifically teach:

i. The determining whether the solution has converged further includes summing the errors;

h. Roy-Chowdhury appears to teach:

i. The determining whether the solution has converged further includes summing the errors (page 400, left-side column, top-half);

==

i. Regarding **claim 21**:

j. Press does not specifically teach:

i. Concluding that the solution has converged if the error is less than a predetermined amount;

k. Roy-Chowdhury appears to teach:

i. Concluding that the solution has converged if the error is less than a predetermined amount (page 400, left-side column, top-half);

==

17. **Claims 3 - 6** are rejected under 35 U.S.C. 103(a) as being unpatentable over Press and Trendall as applied to claims **1 - 2, 12 - 18, 22 - 23, 27 and 32 - 33** above, further in view of Weiskopf (Weiskopf, Daniel; Hopf, Matthias; Ertl, Thomas; "Hardware-Accelerated Visualization of Time-Varying 2D and 3D Vector Fields by Texture Advection via Programmable Per-Pixel Operations", 2001, Proceedings of the Vision Modeling and Visualization Conference 2001).

a. Regarding **claim 3**:

b. Press does not specifically teach:

i. the input includes textures;

c. Weiskopf appears to teach:

i. the input includes textures (pages 668 - 669, section 3 Hardware-Based 2D Texture Advection; and page 668, figure 1, box "Load flow to texture Tv; it would have been obvious that the input includes textures; please note that the partial differential equation on page 667, right-side column, second paragraph, is being solved);

d. The motivation to use the art of Weiskopf with the art of Press and Trendall would have been the benefit recited in Weiskopf that an advantage of the invention is extremely high simulation speed (page 672, right-side column, fourth paragraph that starts with "An advantage . . .").

e. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Weiskopf with the art of Press and Trendall to produce the claimed invention.

==

f. Regarding **claim 4**:

g. Press does not specifically teach:

i. the input includes geometry;

h. Weiskopf appears to teach:

i. the input includes geometry (<u>pages 668 - 669, section 3 Hardware-Based 2D Texture Advection; it would have been obvious that the input includes geometry; please note that the partial differential equation on page 667, right-side column, second paragraph, is being solved</u>);

==

i. Regarding **claim 5**:

j. Press does not specifically teach:

i. the geometry is selected from the group consisting of polygons, vertex data, points, and lines;

k. Weiskopf appears to teach:

i. the geometry includes points (<u>pages 668 - 669, section 3 Hardware-Based 2D Texture Advection; it would have been obvious that the input includes geometry; please note that the partial differential equation on page 667, right-side column, second paragraph, is being solved</u>);

==

l. Regarding **claim 6**:

m. Press does not specifically teach:

i. the input includes a local area of textures;

n. Weiskopf appears to teach:

i. the input includes a local area of textures (<u>pages 668 - 670, section 3 Hardware-Based 2D Texture Advection; it would have been obvious that the input includes a local area of textures; please note that the partial differential equation on page 667, right-side column, second paragraph, is being solved</u>);

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18. **Claims 7 - 9 and 24 - 25** are rejected under 35 U.S.C. 103(a) as being unpatentable over Press and Trendall and Weiskopf as applied to claims **3 - 6** above, further in view of Ewins (Ewins, Jon P.; Waller,

Marcus D.; White, Martin; Lister, Paul F.; "MIP-Map Level Selection for Texture Mapping", 1998, IEEE Transactions on Visualization and Computer Graphics, Vol. 4, No. 4).

a. Regarding **claim 7**:

b. Press does not specifically teach:

   i. the local area of textures is generated by sampling a texture map;

c. Ewins appears to teach:

   i. sampling a texture map (**pages 318 - 319, section 1.1 Texture Filtering**);

d. The motivation to use the art of Ewins with the art of Press and Trendall and Weiskopf would have been the benefit recited in Ewins that texture mapping allows a high degree of visual complexity without the expense of overly complex geometric modeling (**page 317, section 1 Introduction, and Abstract**).

e. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Ewins with the art of Press and Trendall and Weiskopf to produce the claimed invention.

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f. Regarding **claim 8**:

g. Press does not specifically teach:

   i. the local area of textures is filtered;

h. Ewins appears to teach:

   i. the local area of textures is filtered (**pages 318 - 319, section 1.1 Texture Filtering**);

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i. Regarding **claim 9**:

j. Press does not specifically teach:

   i. the local area of textures is filtered utilizing a plurality of filters;

k. Ewins appears to teach:

   i. the local area of textures is filtered utilizing a plurality of filters (**pages 318 - 319, section 1.1 Texture Filtering**);

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l. Regarding **claim 24**:

m. Press does not specifically teach:

   i. the filtering is carried out using a programmable filter;

n. Ewins appears to teach:

   i. the filtering is carried out using a programmable filter (<u>pages 318 - 319, section 1.1 Texture Filtering</u>);

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o. Regarding **claim 25**:

p. Press does not specifically teach:

   i. the filtering is carried out using a non-programmable filter;

q. Ewins appears to teach:

   i. the filtering is carried out using a non-programmable filter (<u>pages 318 - 319, section 1.1 Texture Filtering</u>);

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19. **Claims 26, 28 and 30 - 31** are rejected under 35 U.S.C. 103(a) as being unpatentable over Press (Press, William H.; Flannery, Brian P.; Teukolsky, Saul A.; Vetterling, William T.; "Numerical Recipes in C", 1988, Cambridge University Press) in view of Trendall (Trendall, Chris; Stewart, A. James; "General Calculations using graphics hardware, with application to interactive caustics", June 2000, "Rendering Techniques 2000: 11th Eurographics Workshop on Rendering").

a. Regarding **claim 26**:

b. Press appears to teach:

   i. Processing input (<u>pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that input is required to solve a partial differential equation, especially given the statement that an initial distribution relaxes to an equilibrium distribution on page 673</u>);

   ii. Processing input to generate a solution to partial differential equations (<u>pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems</u>);

   iii. Wherein the solution to the partial differential equation is generated (<u>pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems</u>);

c. Press does not specifically teach:

i. *A hardware graphics pipeline for* processing input to generate a solution to partial differential equations wherein the solution to the partial differential equation is generated *utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline*.

d. Trendall appears to teach:

i. A hardware graphics pipeline for processing the input to generate the solution to a partial differential equation wherein the solution to the partial differential equation is generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline (*page 1, Title; page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

e. The motivation to use the art of Trendall with the art of Press would have been the benefit recited in Trendall that calculations on functions or vector fields can be performed very quickly in graphics hardware (*page 3, section 3 Mathematical capabilities of graphics hardware, third paragraph*).

f. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Trendall with the art of Press to produce the claimed invention.

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g. Regarding **claim 28**:

h. Press appears to teach:

i. Receiving boundary conditions (pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that boundary conditions are required to solve a partial differential equation, especially since the title of the section recites Boundary Value problems);

ii. Computing the solution to generate the solution to the partial differential equations involving the boundary conditions (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems**);

iii. Determining whether the solution has converged (**page 674, first paragraph, subsection that starts with "Thus the algorithm . . .", sentence, "This procedure is then iterated until convergence."**);

iv. If the solution has not converged, repeating the computing and determining (**page 674, first paragraph, subsection that starts with "Thus the algorithm . . .", sentence, "This procedure is then iterated until convergence."**);

v. wherein the solution to the partial differential equation is generated (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems**);

i. Press does not specifically teach:

i. Computing the solution to the partial differential equations involving the boundary conditions *at least some of the computing done in the hardware graphics pipeline*;

ii. wherein the solution to the partial differential equation is generated *utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline*.

j. Trendall appears to teach:

i. Receiving input in the hardware graphics pipeline (*page 9, section 5 Implementation results, first paragraph; page 7, second paragraph that starts with "Since the imaging pipeline . . ."; it would have been obvious that in order for the pipeline to perform a convolution that input was received*);

ii. Computing the solution to the partial differential equations at least some of the computing done in the hardware graphics pipeline wherein the solution to the partial differential equation is generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline (*page 1, Title; page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

k. The motivation to use the art of Trendall with the art of Press would have been the benefit recited in Trendall that calculations on functions or vector fields can be performed very quickly in graphics hardware (*page 3, section 3 Mathematical capabilities of graphics hardware, third paragraph*).

l. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Trendall with the art of Press to produce the claimed invention.

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m. Regarding **claim 30**:

n. Press appears to teach:

i. Receiving a first input (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that input is required to solve a partial differential equation, especially given the statement that an initial distribution relaxes to an equilibrium distribution on page 673**);

ii. Processing the first input to generate a solution to a partial differential equation (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems**);

iii. wherein the solution to the partial differential equation is generated (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems**);

o. Press does not specifically teach:

i. Receiving a first input *into a hardware graphics pipeline*;

ii. Processing the first input to generate a solution to a partial differential equation *utilizing the hardware graphics pipeline*;

iii. Receiving a second input into the hardware graphics pipeline;

iv. Rendering the 3D graphics image utilizing the hardware graphics pipeline, wherein the rendering utilizes the second input and the result of the processing of the first input;

v. wherein the solution to the partial differential equation is *generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline*.

p. Trendall appears to teach:

i. Receiving a first input into a hardware graphics pipeline (*page 9, section 5 Implementation results, first paragraph; page 7, second paragraph that starts with "Since the imaging pipeline . . ."; it would have been obvious that in order for the pipeline to perform a convolution that input was received*);

ii. Processing the first input to generate a solution to a partial differential equation utilizing the hardware graphics pipeline (*page 1, Title; page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

iii. Receiving a second input into the hardware graphics pipeline (**pages 8 - 9, section 4.3 Heightfield generation; it would have been obvious that generating the heightfield used a second input into the hardware graphics pipeline**);

iv. Rendering the 3D graphics image utilizing the hardware graphics pipeline, wherein the rendering utilizes the second input and the result of the processing of the first input (page 9, section 5; and especially page 13, figure 2);

v. wherein the solution to the partial differential equation is generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline (*page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

q. The motivation to use the art of Trendall with the art of Press would have been the benefit recited in Trendall that calculations on functions or vector fields can be performed very quickly in graphics hardware (*page 3, section 3 Mathematical capabilities of graphics hardware, third paragraph*).

r. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Trendall with the art of Press to produce the claimed invention.

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s. Regarding **claim 31**:

t. Press appears to teach:

i. The first input comprises boundary conditions (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that boundary conditions are required to solve a partial differential equation, especially since the title of the section recites Boundary Value problems**);

ii. determining whether the solution has converged (**page 674, first paragraph, subsection that starts with "Thus the algorithm . . .", sentence, "This procedure is then iterated until convergence."**);

iii. If the solution has not converged, repeating the computing and determining (**page 674, first paragraph, subsection that starts with "Thus the algorithm . . .", sentence, "This procedure is then iterated until convergence."**);

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20. **Claim 29** is rejected under 35 U.S.C. 103(a) as being unpatentable over Press (Press, William H.; Flannery, Brian P.; Teukolsky, Saul A.; Vetterling, William T.; "Numerical Recipes in C", 1988, Cambridge University Press) in view of Weiskopf (Weiskopf, Daniel; Hopf, Matthias; Ertl, Thomas; "Hardware-Accelerated Visualization of Time-Varying 2D and 3D Vector Fields by Texture Advection via Programmable Per-Pixel Operations", 2001, Proceedings of the Vision Modeling and Visualization Conference 2001), further in view of Roy-Chowdhury (Roy-Chowdhury, Amber; Bellas, Nikolas; Banerjee, Prithviraj; "Algorithm-Based Error-Detection Schemes for Iterative Solution of Partial Differential Equations",1996, IEEE Transactions on Computers, Vol. 45, No. 4) further in view of Trendall (Trendall, Chris; Stewart, A. James; "General Calculations using graphics hardware, with application to interactive caustics", June 2000, "Rendering Techniques 2000: 11th Eurographics Workshop on Rendering").

a. Regarding **claim 29**:

b. Press appears to teach:

i. Receiving boundary conditions (**pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems; it would have been obvious that boundary conditions**

<u>are required to solve a partial differential equation, especially since the title of the section recites Boundary Value problems</u>);

ii. computing the solution to the partial differential equation utilizing a relaxation operation involving the boundary conditions (<u>pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems</u>);

iii. determining whether the solution has converged (<u>page 674, first paragraph, subsection that starts with "Thus the algorithm . . .", sentence, "This procedure is then iterated until convergence."</u>);

iv. If the solution has not converged, repeating the computing and determining (<u>page 674, first paragraph, subsection that starts with "Thus the algorithm . . .", sentence, "This procedure is then iterated until convergence."</u>);

v. if the solution has converged, incrementing a time value (<u>page 658, second paragraph, sentence that starts, "To solve equation (17.2.8) . . ."</u>); and

vi. repeating the foregoing operations using the incremented time value (<u>page 658, second paragraph, sentence that starts, "To solve equation (17.2.8) . . ."</u>).

vii. wherein the solution to the partial differential equation is generated conditions (<u>pages 673-676, section 17.5 Relaxation Methods for Boundary Value Problems</u>);

c. Press does not specifically teach:

i. Receiving boundary conditions <u>*in the form of at least one of geometry and textures;*</u>

ii. computing the solution to the partial differential equation utilizing a relaxation operation involving the boundary conditions <u>*at least some of the computing done in the hardware graphics pipeline;*</u>

iii. determining whether the solution has converged by:

(1) calculating the errors,

(2) summing the errors, and

iv. concluding that the solution has converged if the sum of errors is less than a predetermined amount;

v. wherein the solution to the partial differential equation is generated <u>*utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline*</u>.

d. Weiskopf appears to teach:

i. Receiving boundary conditions in the form of at least one of geometry and textures (pages 668 - 669, section 3 Hardware-Based 2D Texture Advection; and page 668, figure 1, box "Load flow to texture Tv; it would have been obvious that boundary conditions were loaded in the form of a texture; please note that the partial differential equation on page 667, right-side column, second paragraph, is being solved);

e. Roy-Chowdhury appears to teach:

i. determining whether the solution has converged by:

(1) calculating the errors (page 400, left-side column, top-half),

(2) summing the errors (page 400, left-side column, top-half),, and

ii. concluding that the solution has converged if the sum of errors is less than a predetermined amount (page 400, left-side column, top-half),;

f. Trendall appears to teach:

i. wherein the solution to the partial differential equation is generated utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline (*page 1, Abstract; page 1, section 1 Introduction; page 8, section 4.2 Hardware Algorithm; and page 2, section 2.2 Refractive Caustics; the solution of the caustic is a solution to an electromagnetic field problem described by a partial differential equation*);

g. The motivation to use the art of Weiskopf with the art of Press would have been the benefit recited in Weiskopf that an advantage is exteremly high simulation speed (page 3, section 3 Mathematical capabilities of graphics hardware, third paragraph).

h. The motivation to use the art of Roy-Chowdhury with the art of Press would have been the benefit recited in Roy-Chowdhury that the presented algorithm-based fault tolerance is an inexpensive method of achieving fault tolerance without requiring any hardware modifications, especially for iterative solution of linear systems arising from discretization of partial differential equations (page 394, Abstract).

i. The motivation to use the art of Trendall with the art of Press would have been the benefit recited in Trendall that calculations on functions or vector fields can be performed very quickly in graphics hardware (*page 3, section 3 Mathematical capabilities of graphics hardware, third paragraph*).

j. Therefore, as discussed above, it would have been obvious to the ordinary artisan at the time of invention to use the art of Weiskopf and the art of Roy-Chowdhury and the art of Trendall with the art of Press to produce the claimed invention.

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21. **Examiner's Note:** Examiner has cited particular columns and line numbers in the references applied to the claims above for the convenience of the applicant. Although the specified citations are representative of the teachings of the art and are applied to specific limitations within the individual claim, other passages and figures may apply as well. It is respectfully requested from the Applicant in preparing responses, to fully consider the references in their entirety as potentially teaching all or part of the claimed invention, as well as the context of the passage as taught by the prior art or disclosed by the Examiner.

Allowable Subject Matter

22. Claims 10 - 11 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims, and correction of other outstanding rejections.

23. As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

24. The following is a statement of reasons for the indication of allowable subject matter:

a. While Press teaches processing input to generate the solution to a partial differential equation, and Trendall teaches receiving input in the hardware graphics pipeline, and processing the input to generate the solution to the partial differential equation utilizing the hardware graphics pipeline, and wherein the solution to the partial differential equation is generated

utilizing the hardware graphics pipeline for enhancing graphics processing operations performed by the hardware graphics pipeline, and Weiskopf teaches the input includes a local area of textures, none of these references taken either alone or in combination with the prior art of record disclose a method for generating a solution to a partial differential equation in a hardware graphics pipeline specifically including:

i. Regarding claim 10, "wherein the local area of textures is filtered utilizing a filter including a plurality of elements."

ii. Regarding claim 11, "wherein the local area of textures is used to sample a texture map to generate a modified local area of textures."

in combination with the remaining features and elements of the claimed invention. It is for these reasons that the Applicant's invention defines over the prior art of record.

Conclusion

25. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Russ Guill whose telephone number is 571-272-7955. The examiner can normally be reached on Monday - Friday 10:00 AM - 6:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Paul Rodriguez can be reached on 571-272-3753. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Any inquiry of a general nature or relating to the status of this application should be directed to the TC2100 Group Receptionist: 571-272-2100.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Russ Guill
Examiner
Art Unit 2123

Paul L. Rodriguez
Primary Examiner
Art Unit ~~2125~~ 2123

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